Climate Change:
Implications for California Agriculture

Maximilian Auffhammer
George Pardee Jr. Professor of Sustainable Development
University of California at Berkeley
National Bureau of Economic Research

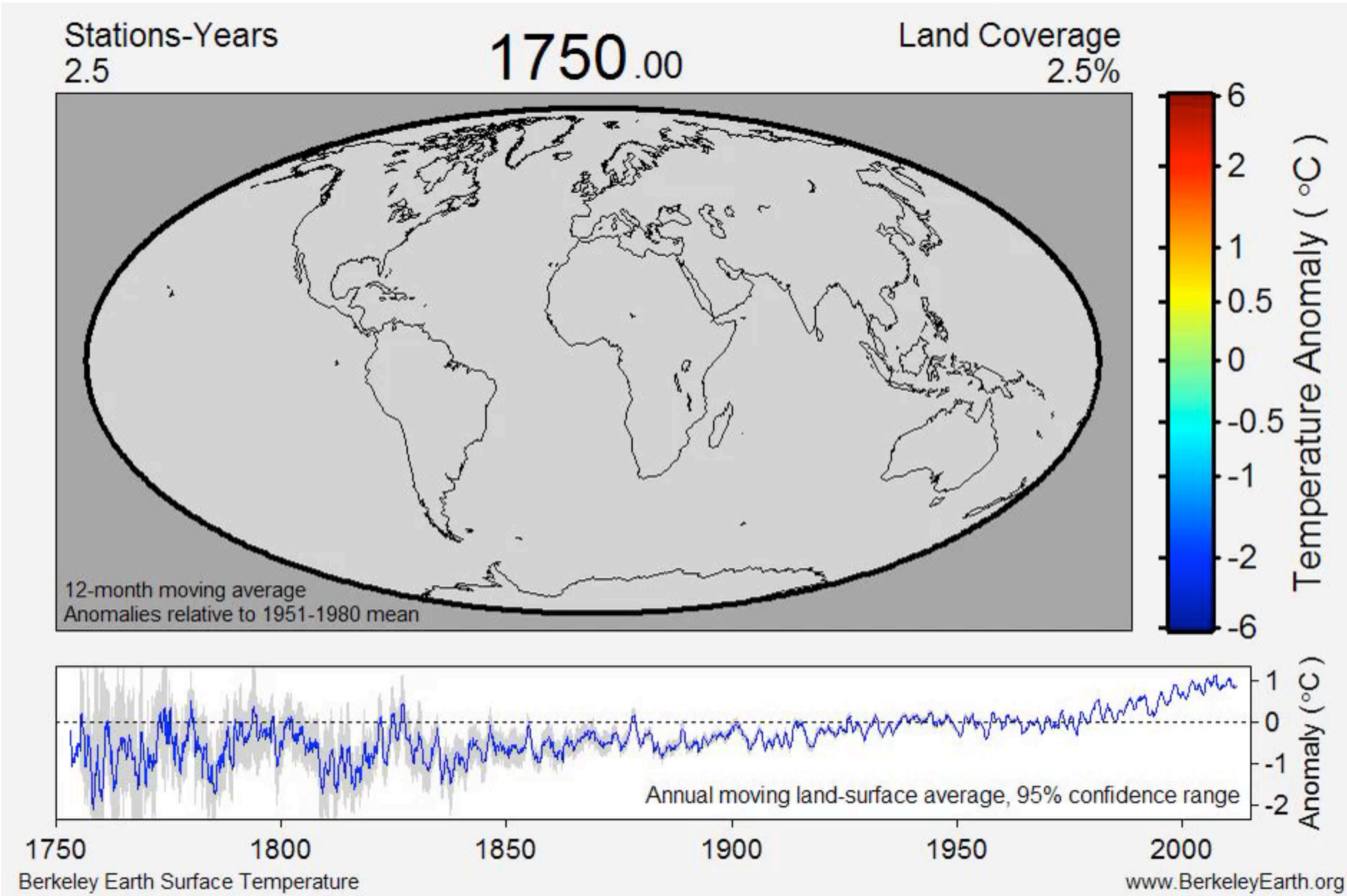
Safeguarding California: Preparing for Climate Risks
Merced, October 9th, 2013

Berkeley
UNIVERSITY OF CALIFORNIA

Agenda for today

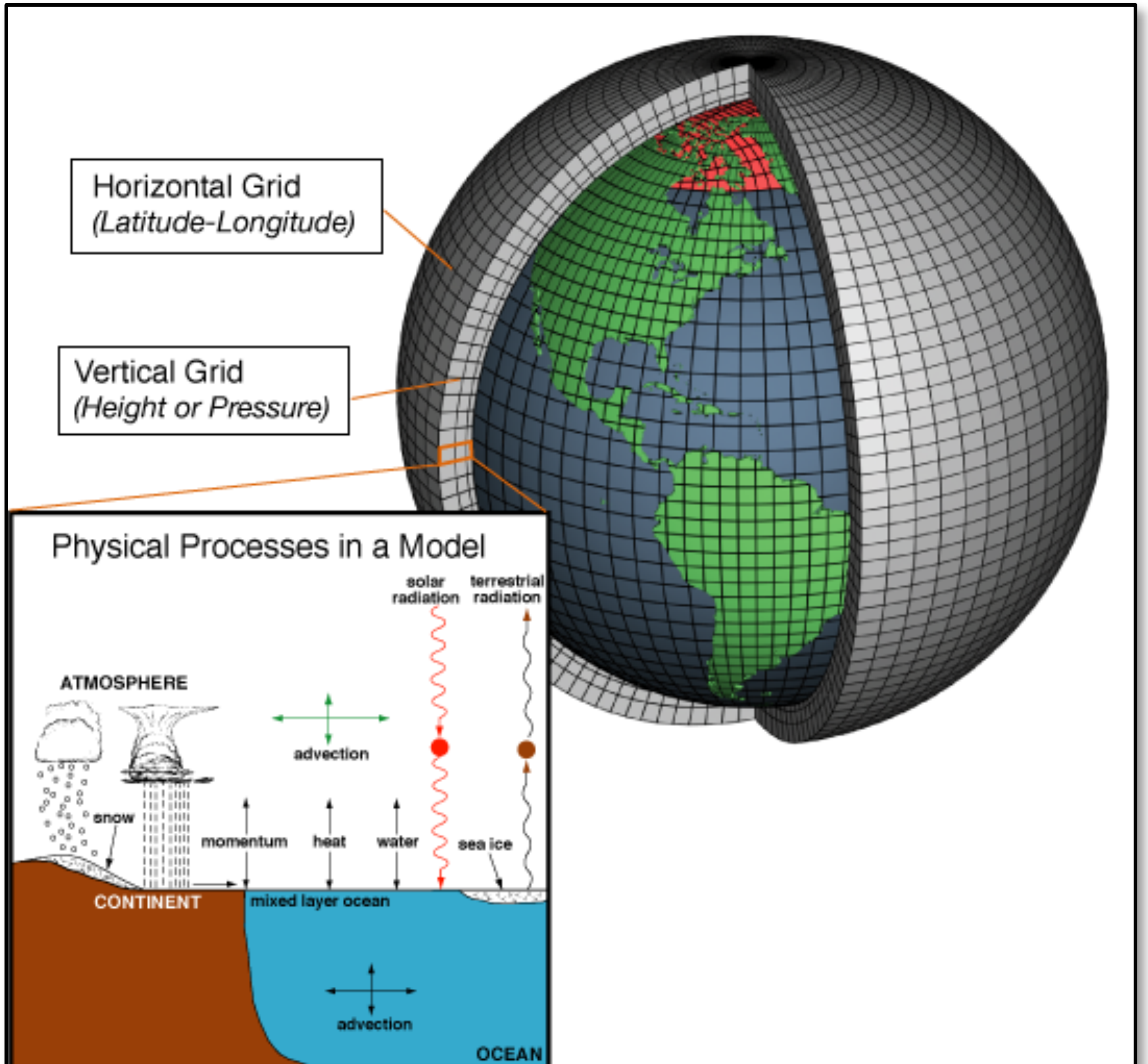
- A quick review of the basics of Climate Change
  - Slow moving impacts
  - Extreme events
- Challenges to Agriculture

Past warming is correlated with latitude



Source: NASA

Predicting Future Climate Change

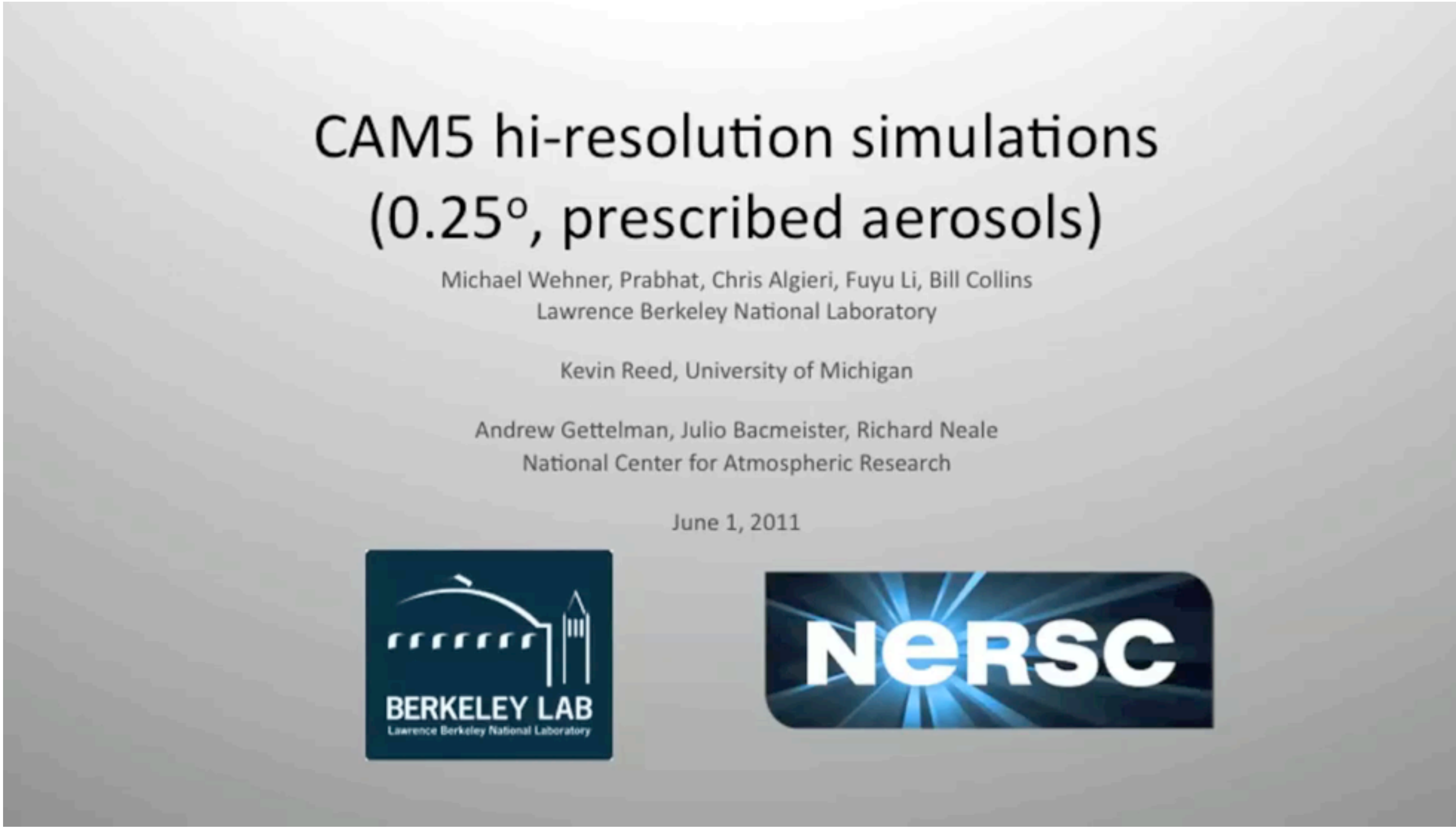


We rely on GCMs to:

- Predict the future
- Understand the past
- Numerical "parallel Earth"

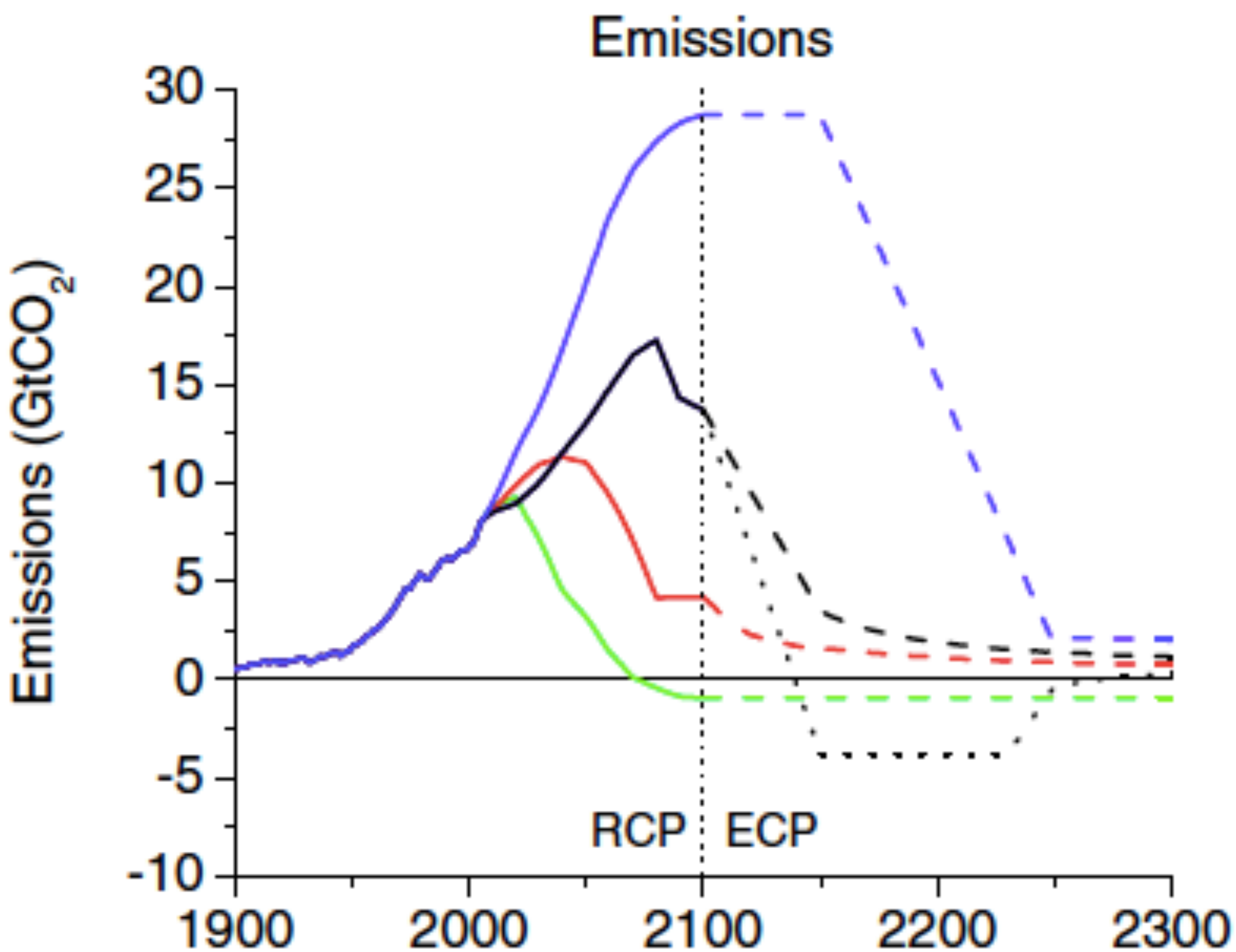
Source: NOAA

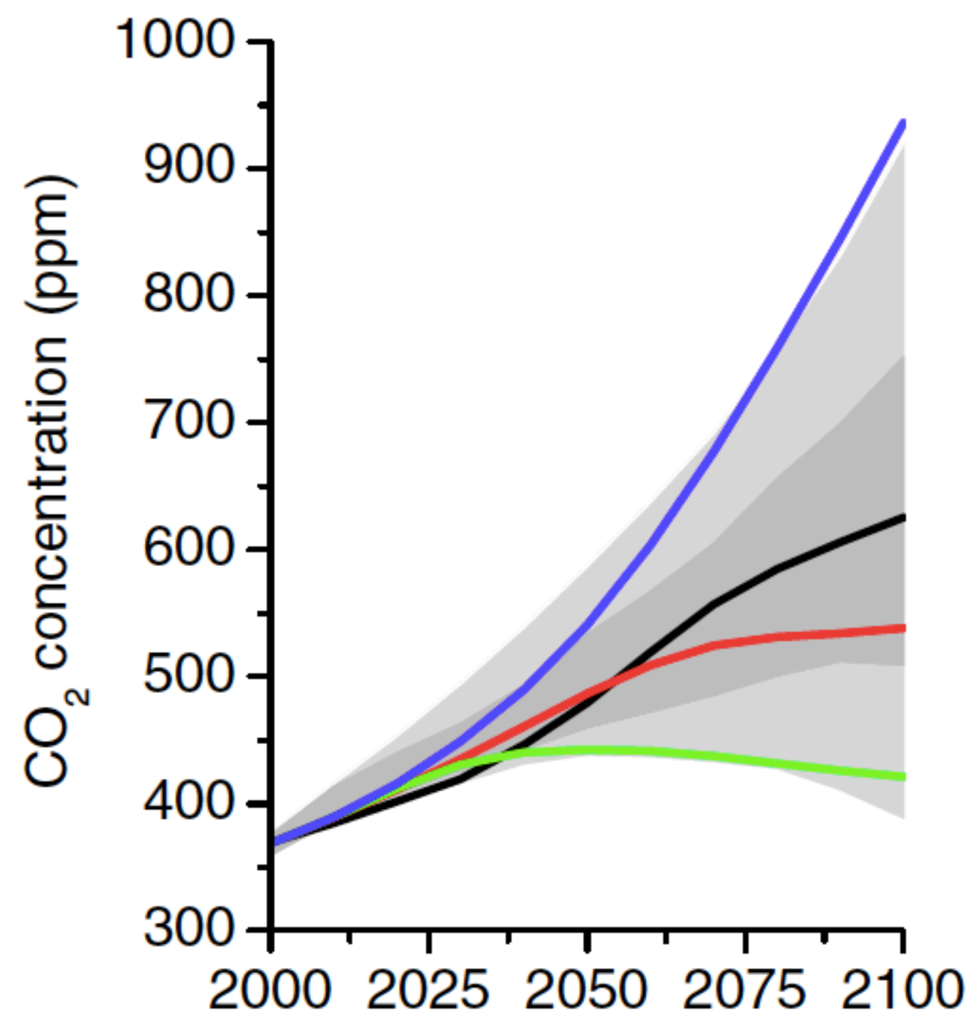
Modeling precipitation is difficult.



Source: Wehner and Prabhat, SCIDEC

Future emissions scenarios not optimistic

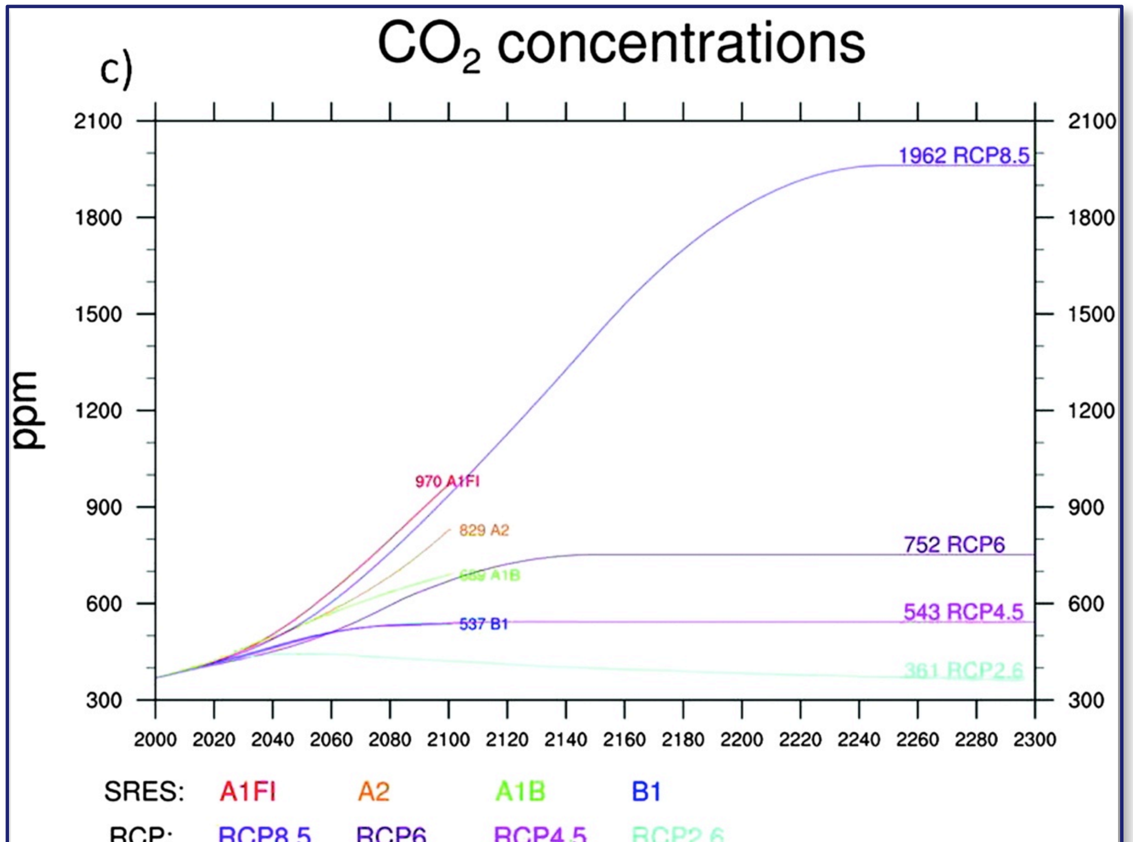


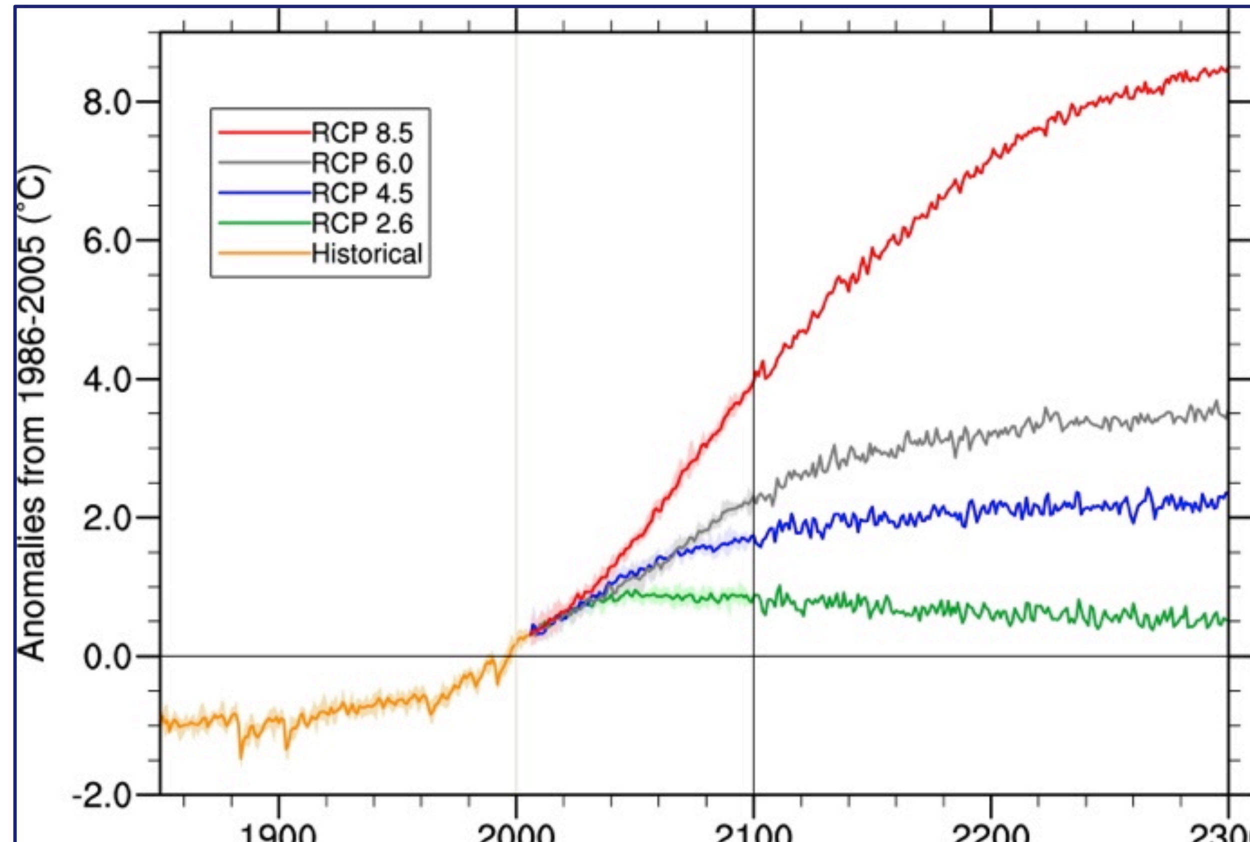


"Representative Concentration Pathways"

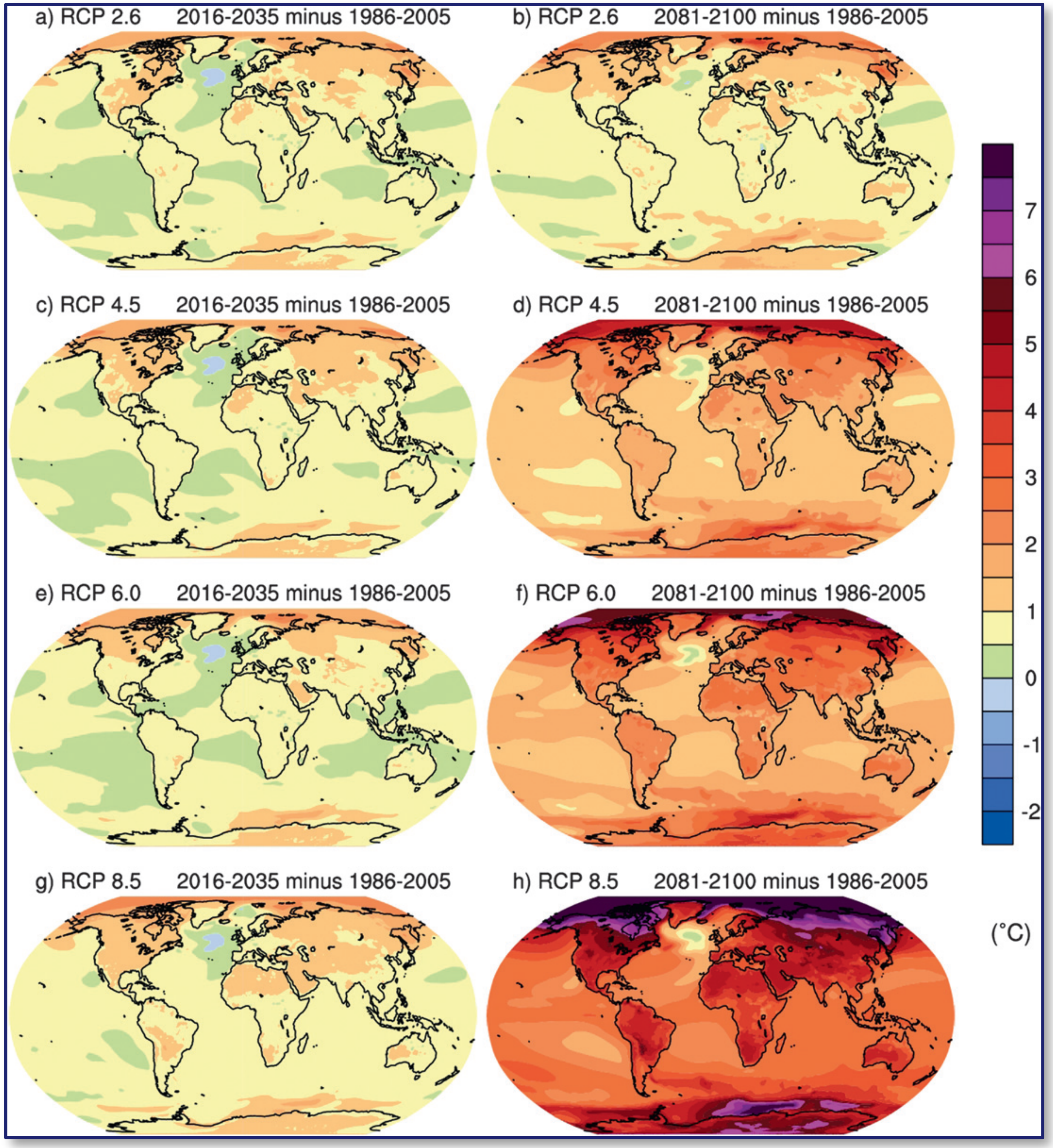
Van Vuuren et al, 2011

The higher emissions, the higher warming





Projected Temperature Increases



Meehl et al, 2012

Less model agreement on projected precipitation patterns

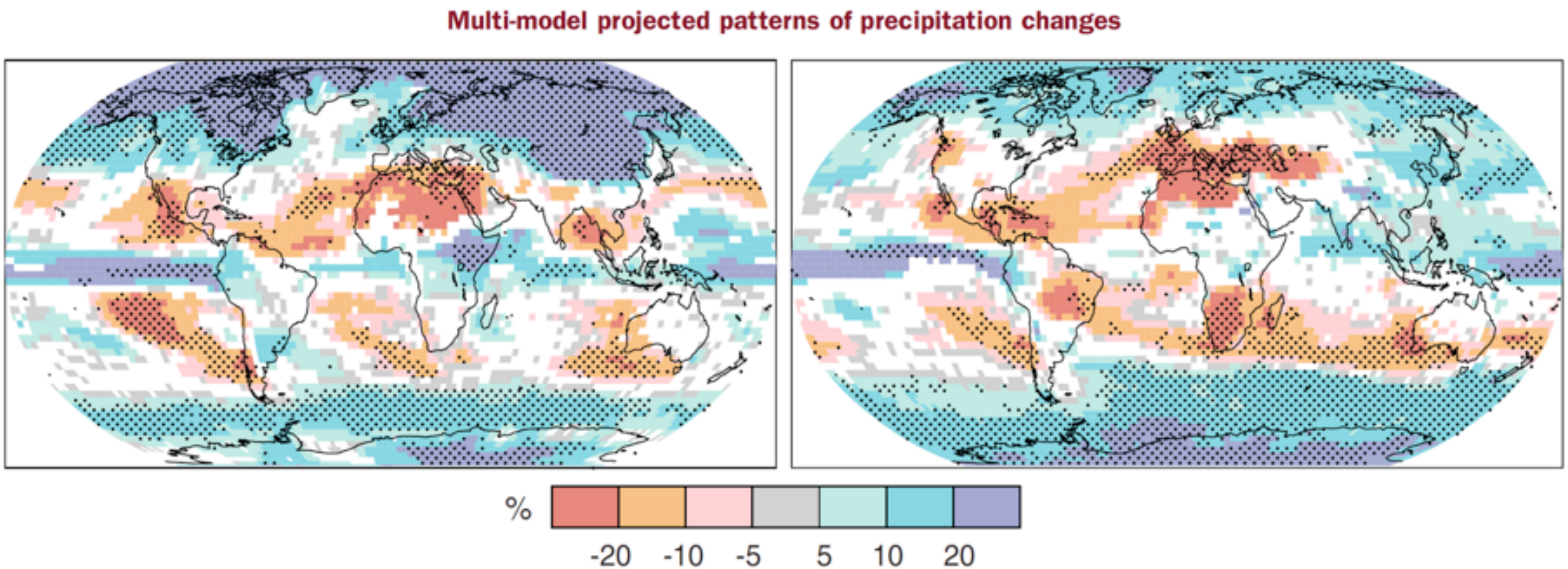
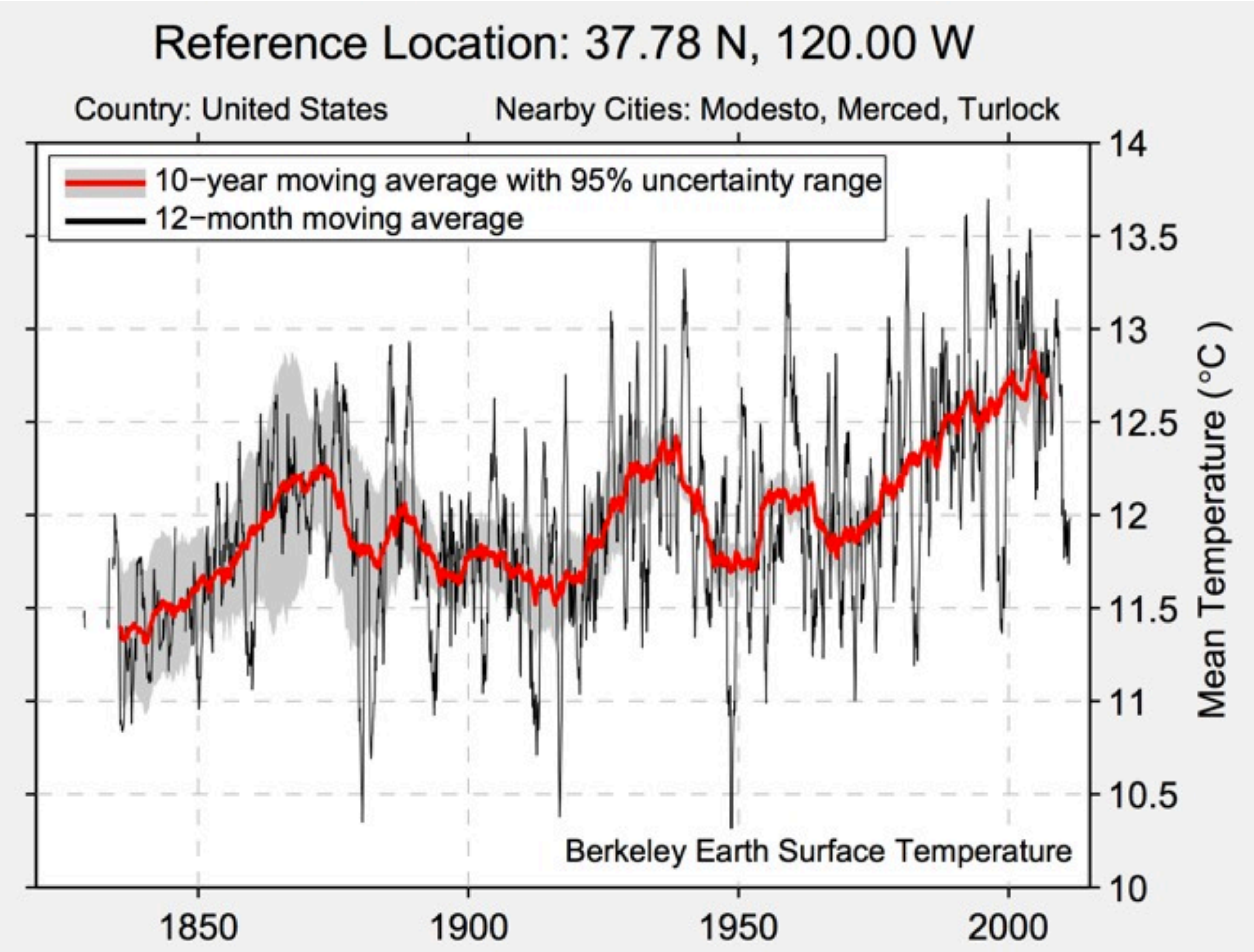
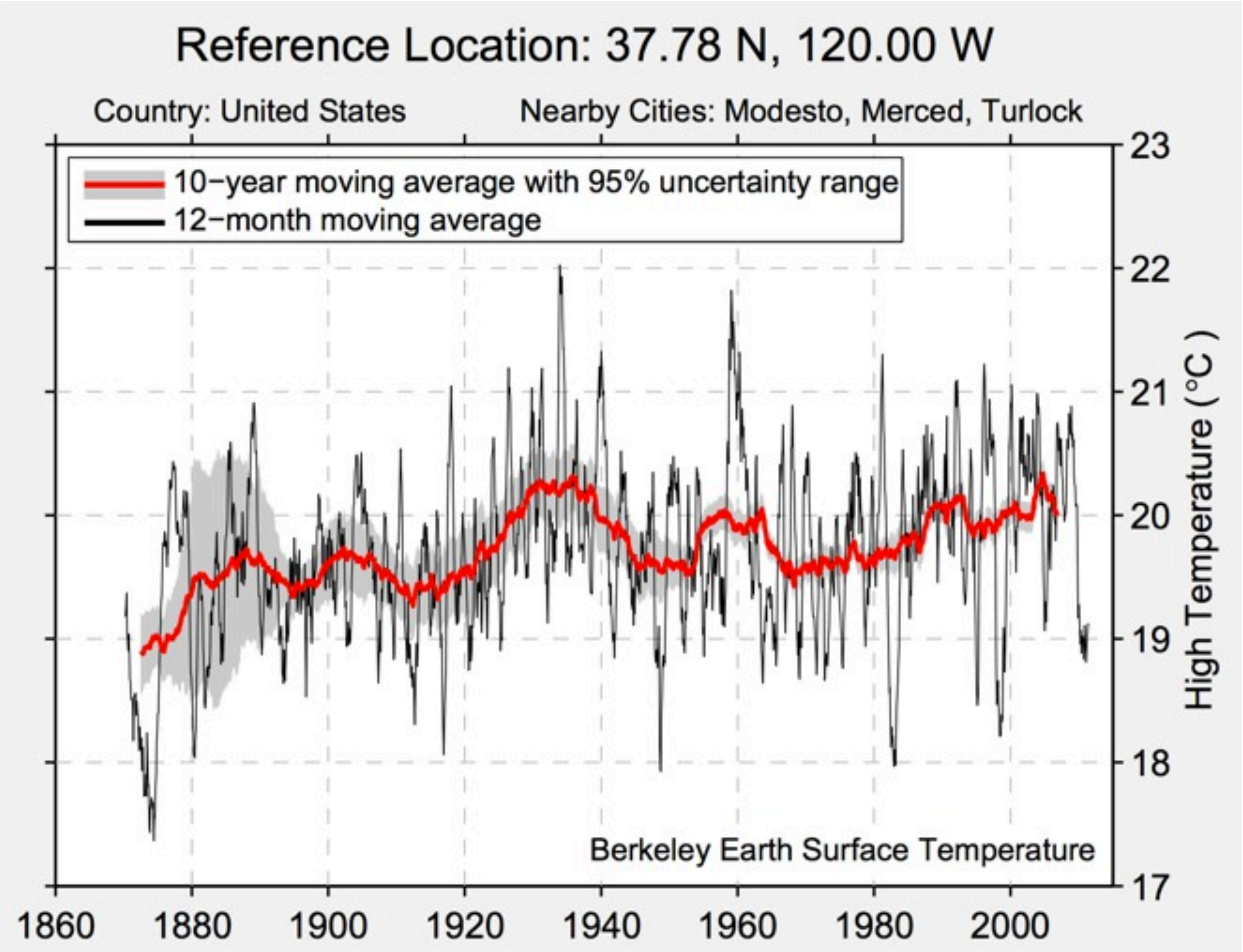


Figure 3.3. Relative changes in precipitation (in percent) for the period 2090-2099, relative to 1980-1999. Values are multi-model averages based on the SRES A1B scenario for December to February (left) and June to August (right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change. {WGI Figure 10.9, SPM}

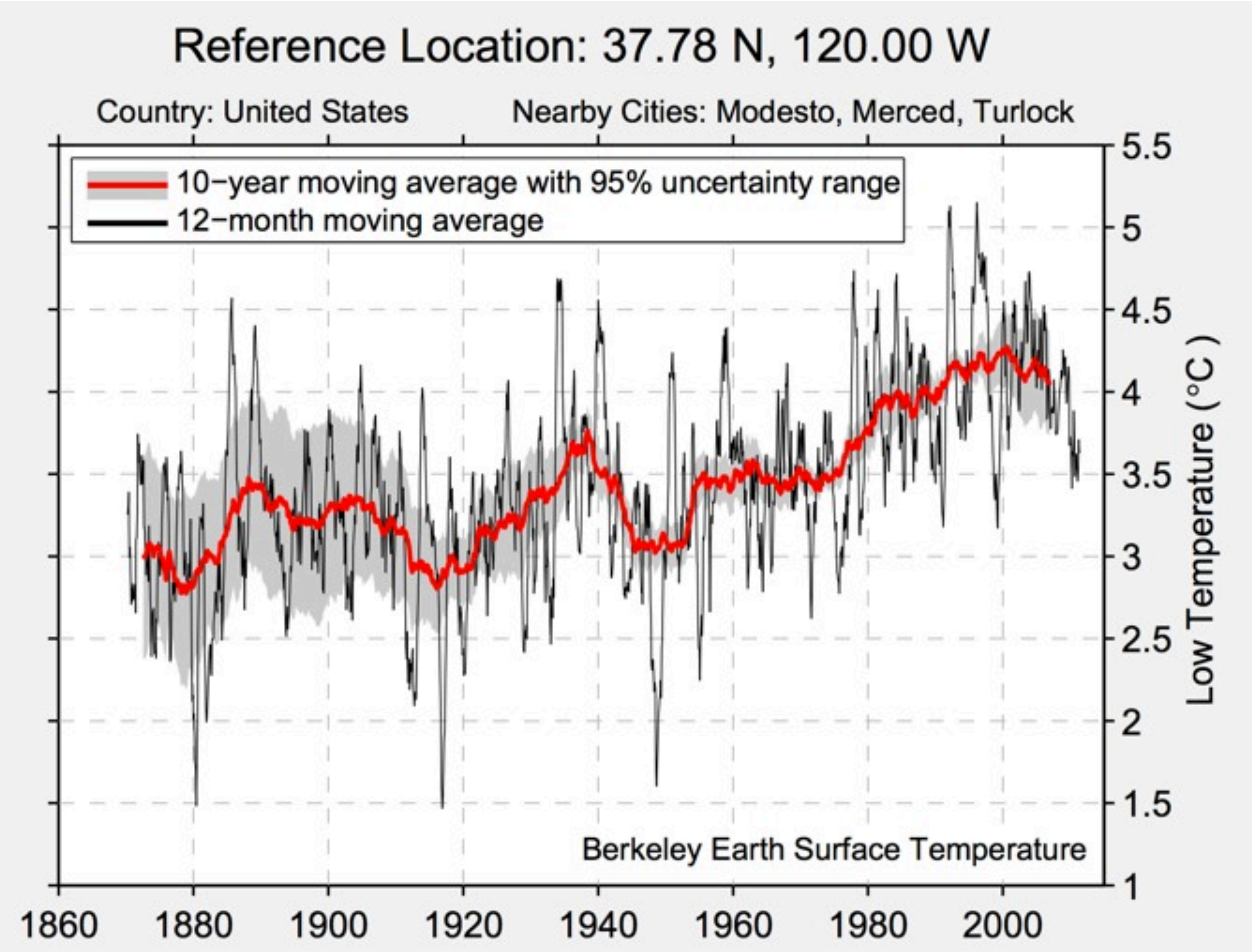
Daily Mean Temperature has risen. Right here.



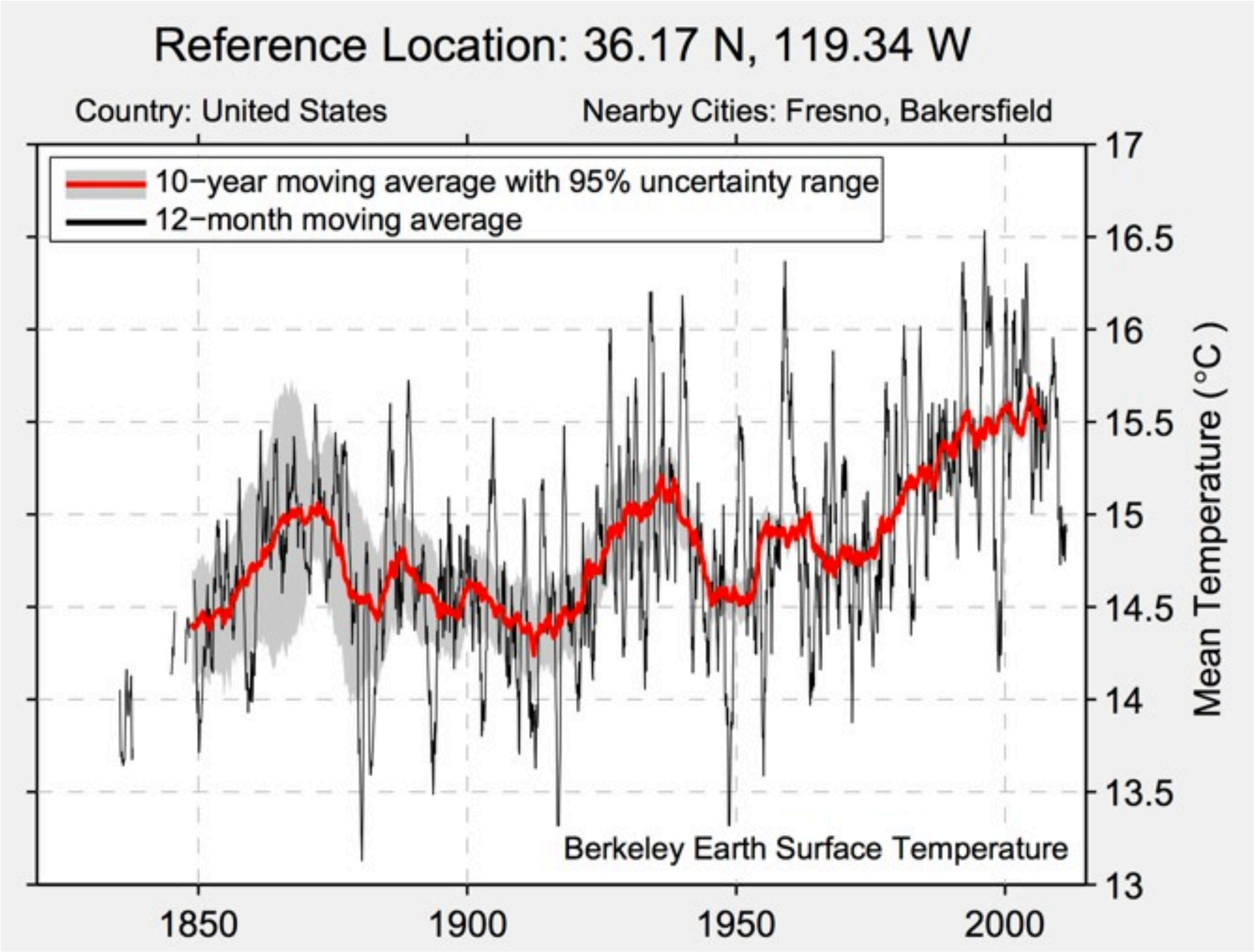
Maximum Temperature rises slowly



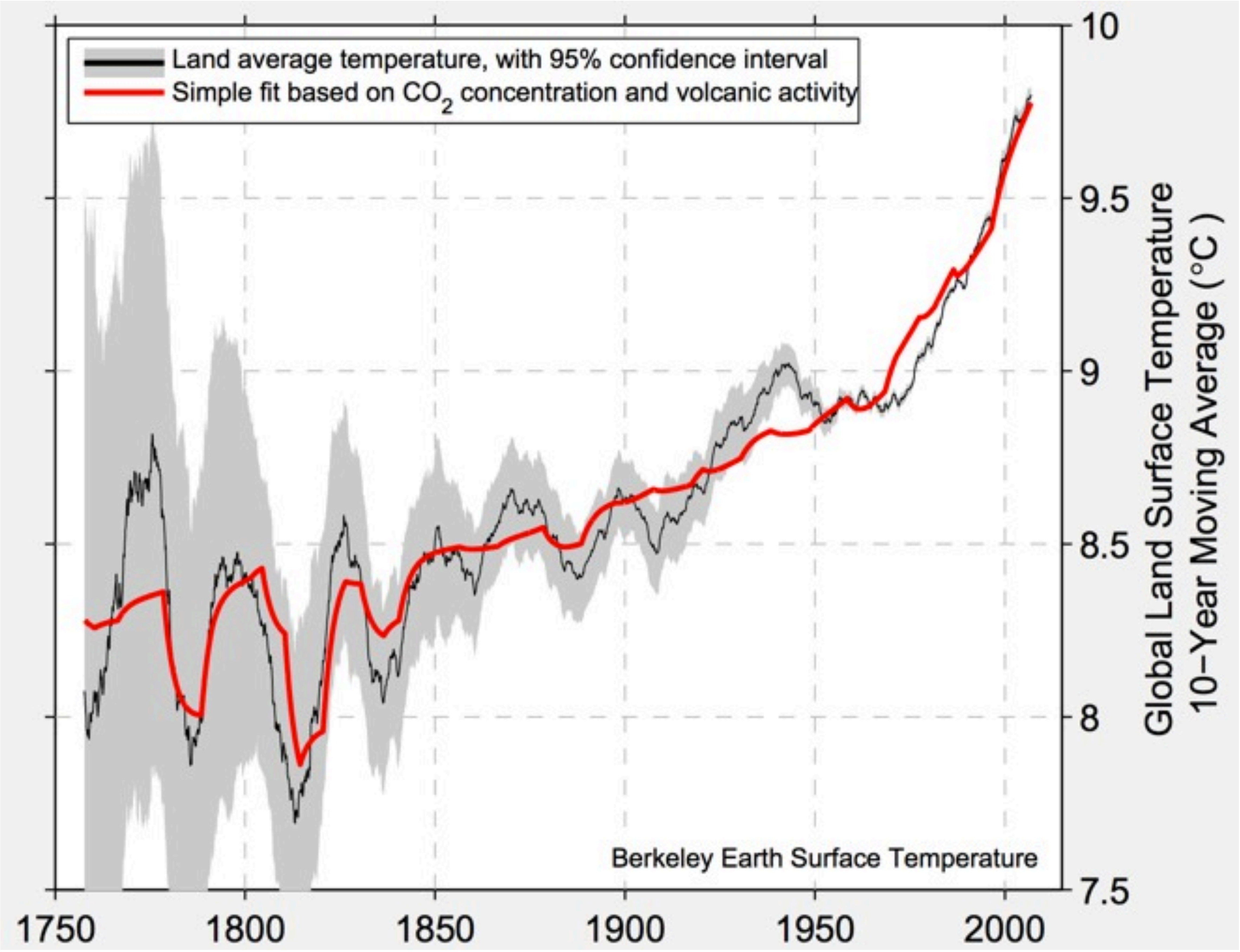
Nights are getting warmer



Same thing is happening in Fresno

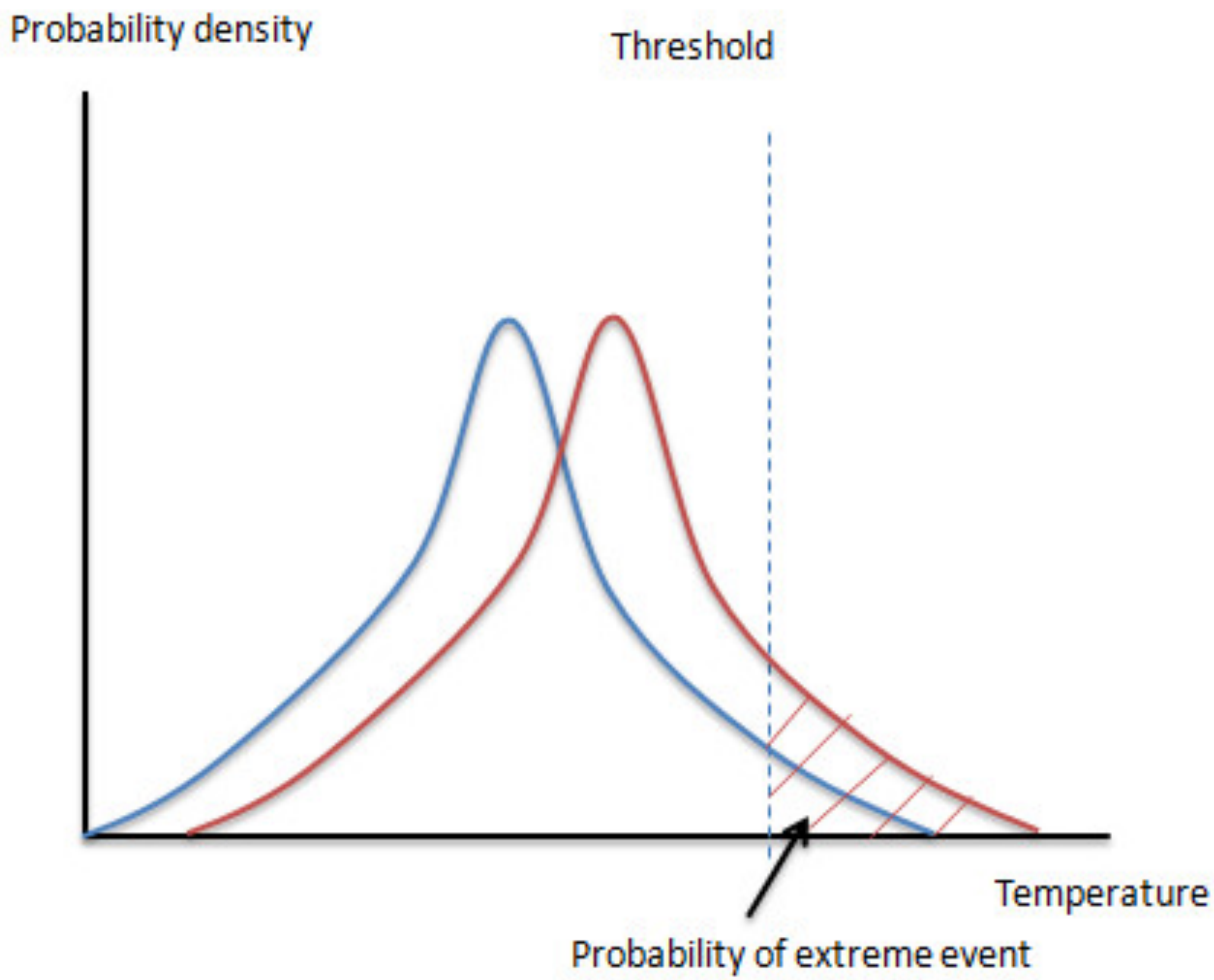


How much of this warming is CO2 and Volcanoes?



Extreme events will become more frequent.

In short, climate is the description of the long-term pattern of weather in a particular area.
Some scientists define climate as the average weather for a particular region and time period, usually taken over 30-years. It's really an average pattern of weather for a particular region (Source: NASA)



Measuring the impacts of climate on agriculture.

The Impact of Global Warming on Agriculture: A Ricardian Analysis

By ROBERT MENDELSOHN, WILLIAM D. NORDHAUS, AND DAIGEE SHAW*

We measure the economic impact of climate on land prices. Using cross-sectional data on climate, farmland prices, and other economic and geophysical data for almost 3,000 counties in the United States, we find that higher temperatures in all seasons except autumn reduce average farm values, while more precipitation outside of autumn increases farm values. Applying the model to a global-warming scenario shows a significantly lower estimated impact of global warming on U.S. agriculture than the traditional production-function approach and, in one case, suggests that, even without CO_2 fertilization, global warming may have economic benefits for agriculture. (*JEL* Q10, Q25)

Impacts are softened through crop switching.

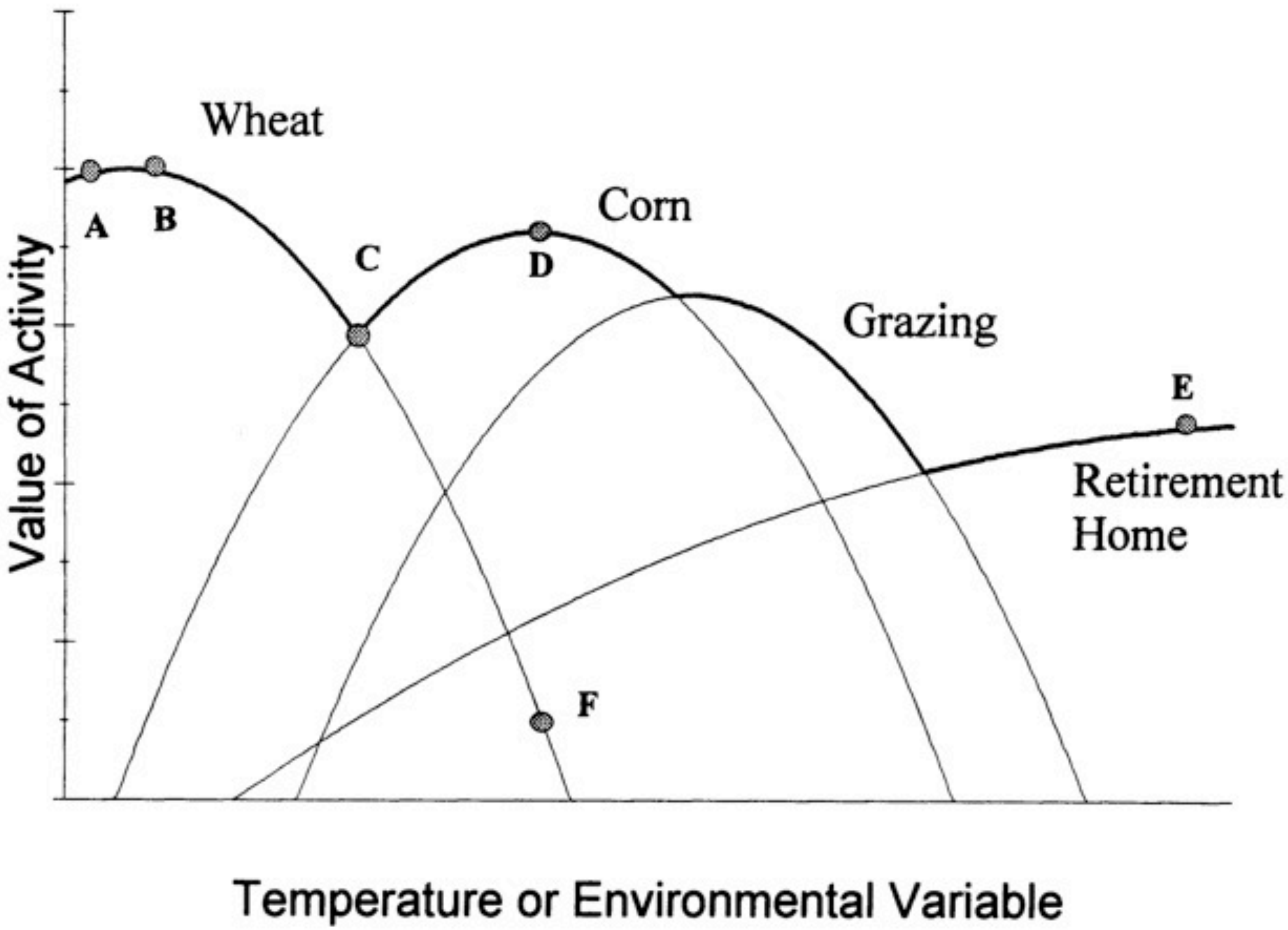
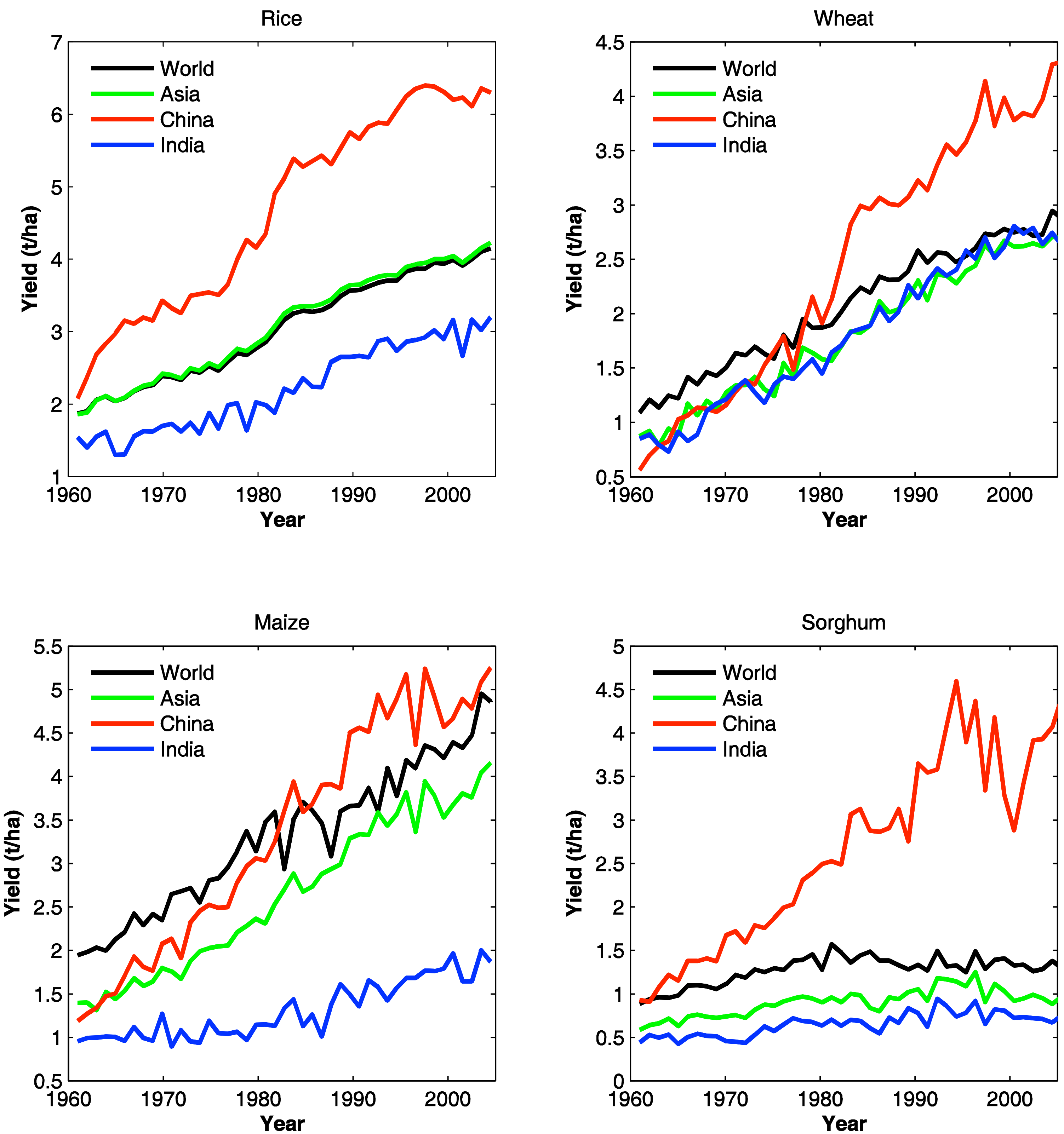
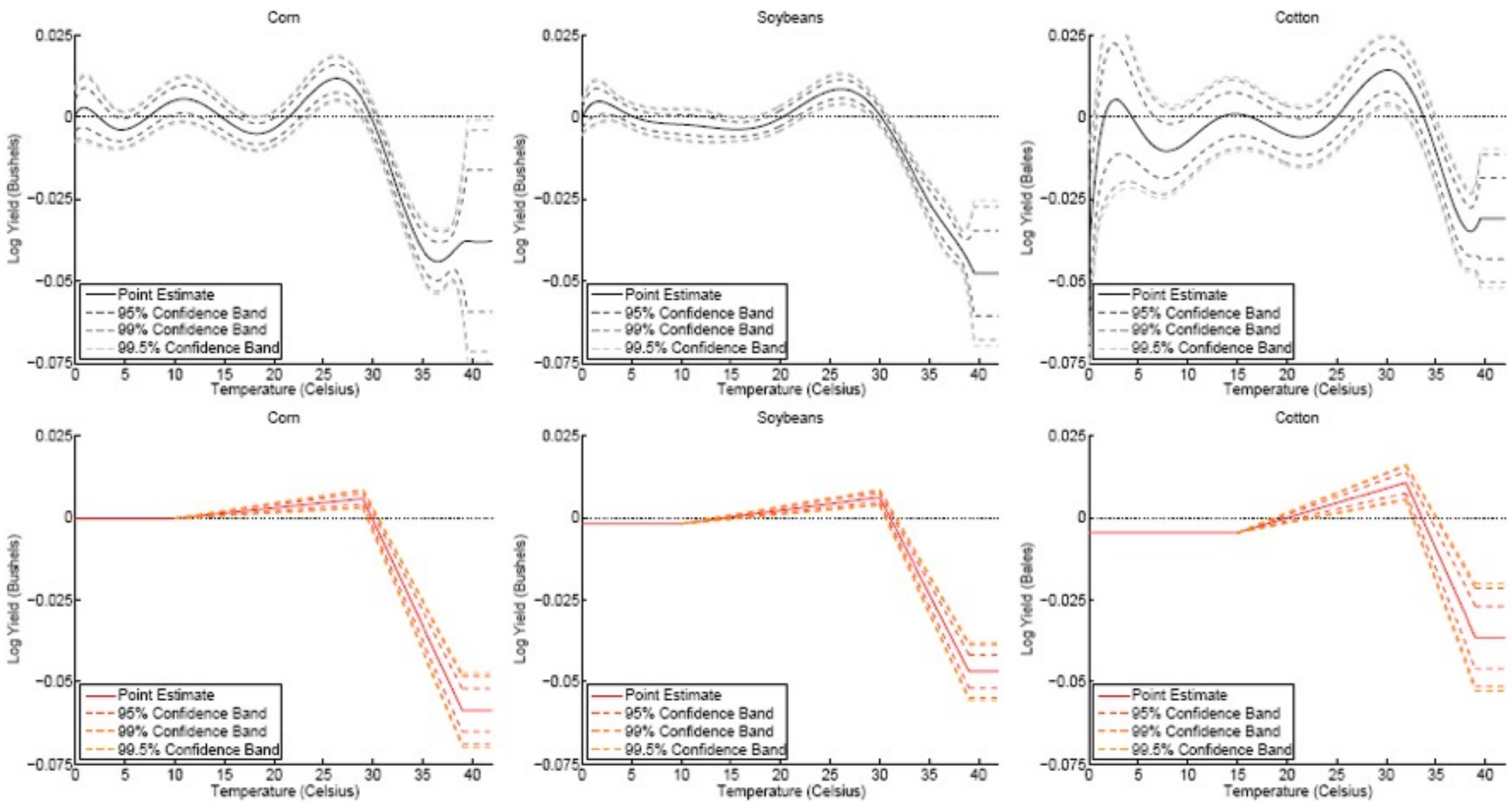


FIGURE 1. BIAS IN PRODUCTION-FUNCTION STUDIES

Global Slowdown in Growth of Yields of Major Crops



US Soy, Wheat and Corn do not like extreme heat.



Impact of climate on perennial crops

Climatic Change (2011) 109 (Suppl 1):S317–S333
DOI 10.1007/s10584-011-0303-6

California perennial crops in a changing climate

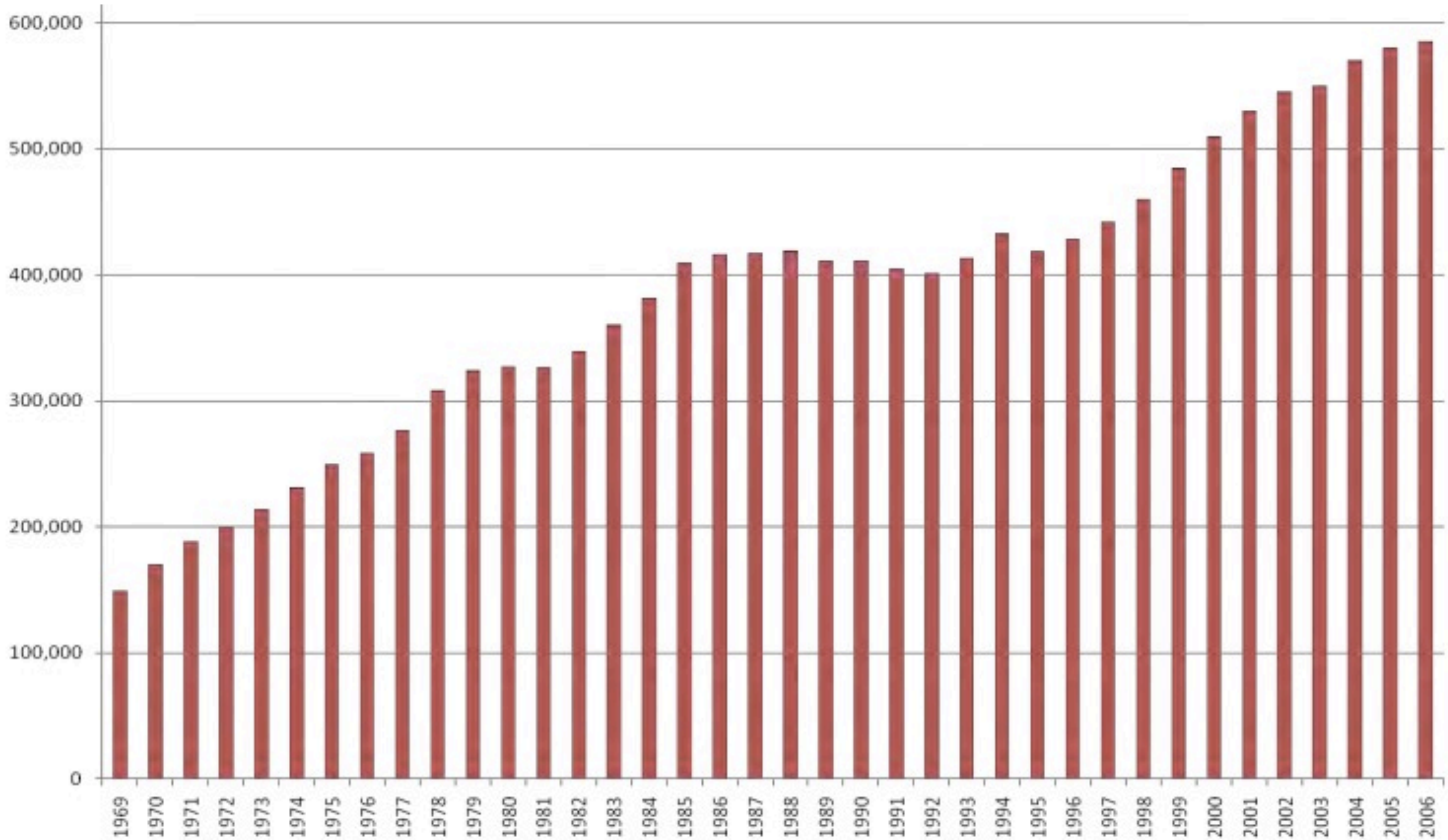
David B. Lobell · Christopher B. Field

Perennials generate significant revenue.

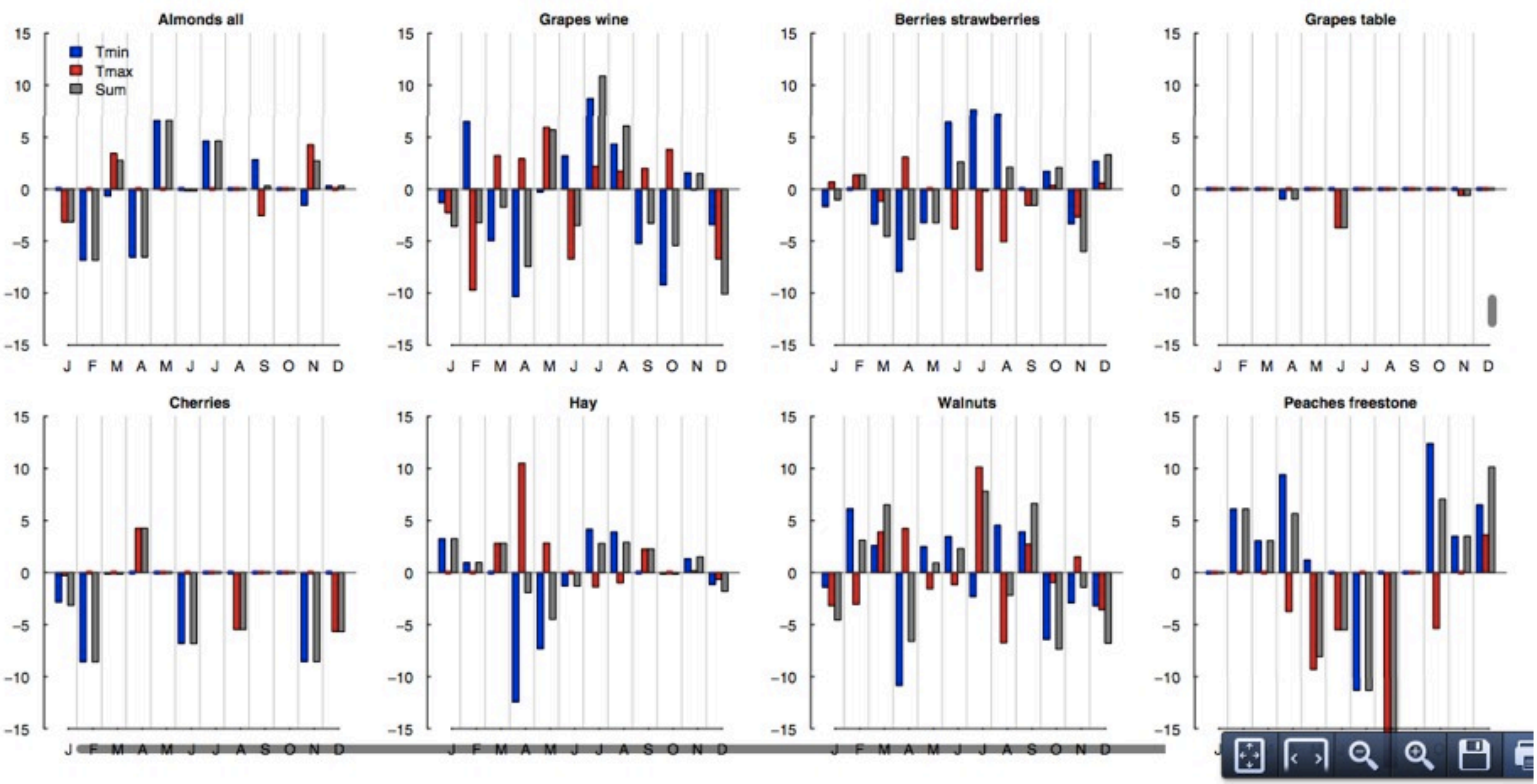
Table 1. Leading perennial crops in California, ranked by 2003–2005 average total statewide gross cash income, in millions of dollars

Rank	Crop	2003	2004	2005	AVERAGE
1	Almonds	1,600	2,189	2,337	2,042
2	Grapes, Wine	1,543	1,605	2,215	1,787
3	Berries, Strawberries*	1,173	1,206	1,110	1,163
4	Hay, All	544	609	703	618
5	Grapes, Raisin	348	616	567	510
6	Walnuts	378	452	540	457
7	Grapes, Table	407	535	384	442
8	Pistachios	145	465	577	396
9	Oranges, Navel	290	418	363	357
10	Avocados	365	375	280	340
11	Lemons	218	271	319	270
12	Berries, Bushberries	146	209	224	193
13	Oranges, Valencia	131	142	218	164
14	Peaches, Freestone	139	110	157	135
15	Peaches, Clingstone	108	141	122	124
16	Plums, Dried	132	121	81	111
17	Nectarines	119	86	120	109
18	Cherries	107	123	85	105
19	Grapefruit	69	68	130	89
20	Plums	87	74	92	85

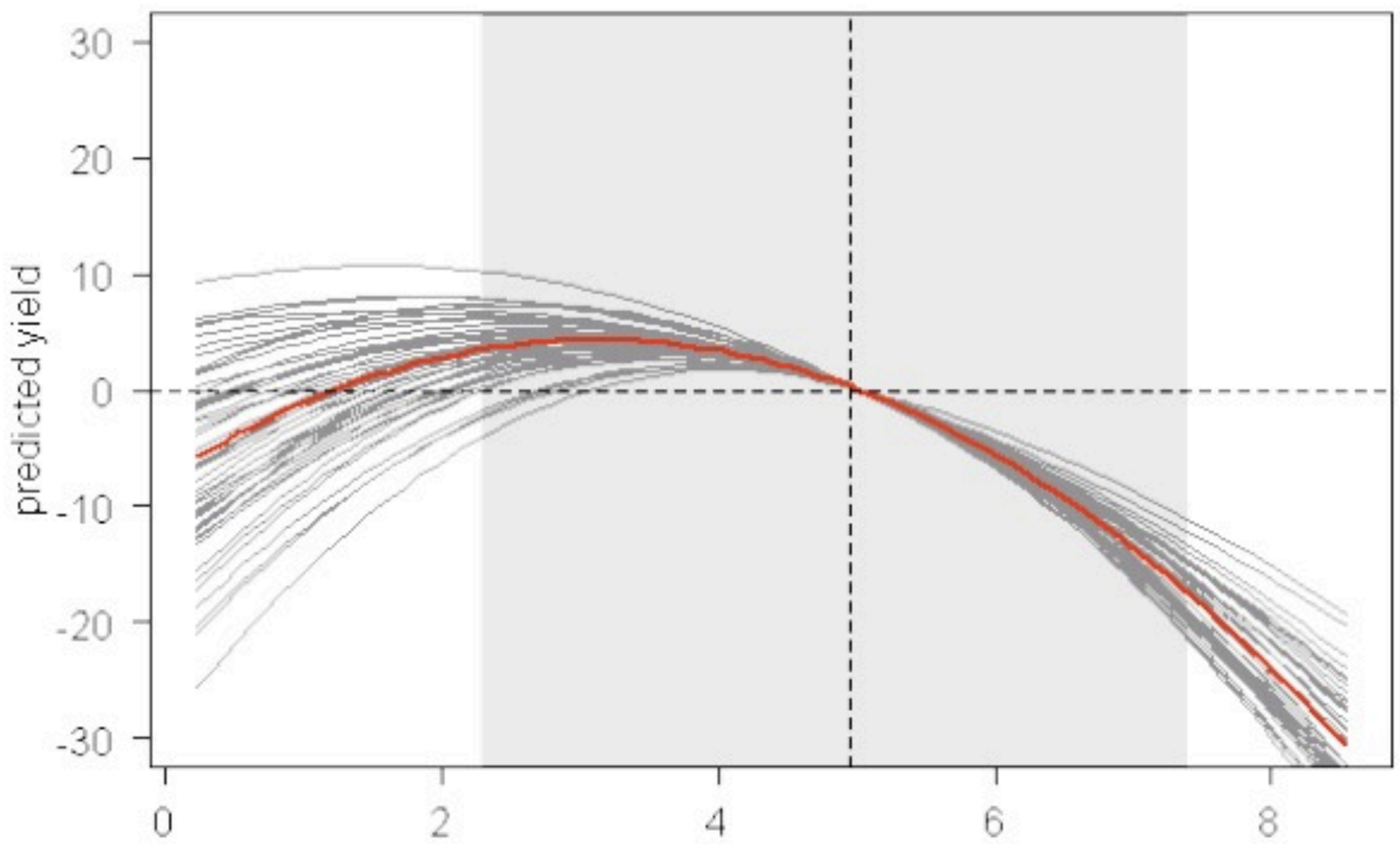
Almond area has exploded.



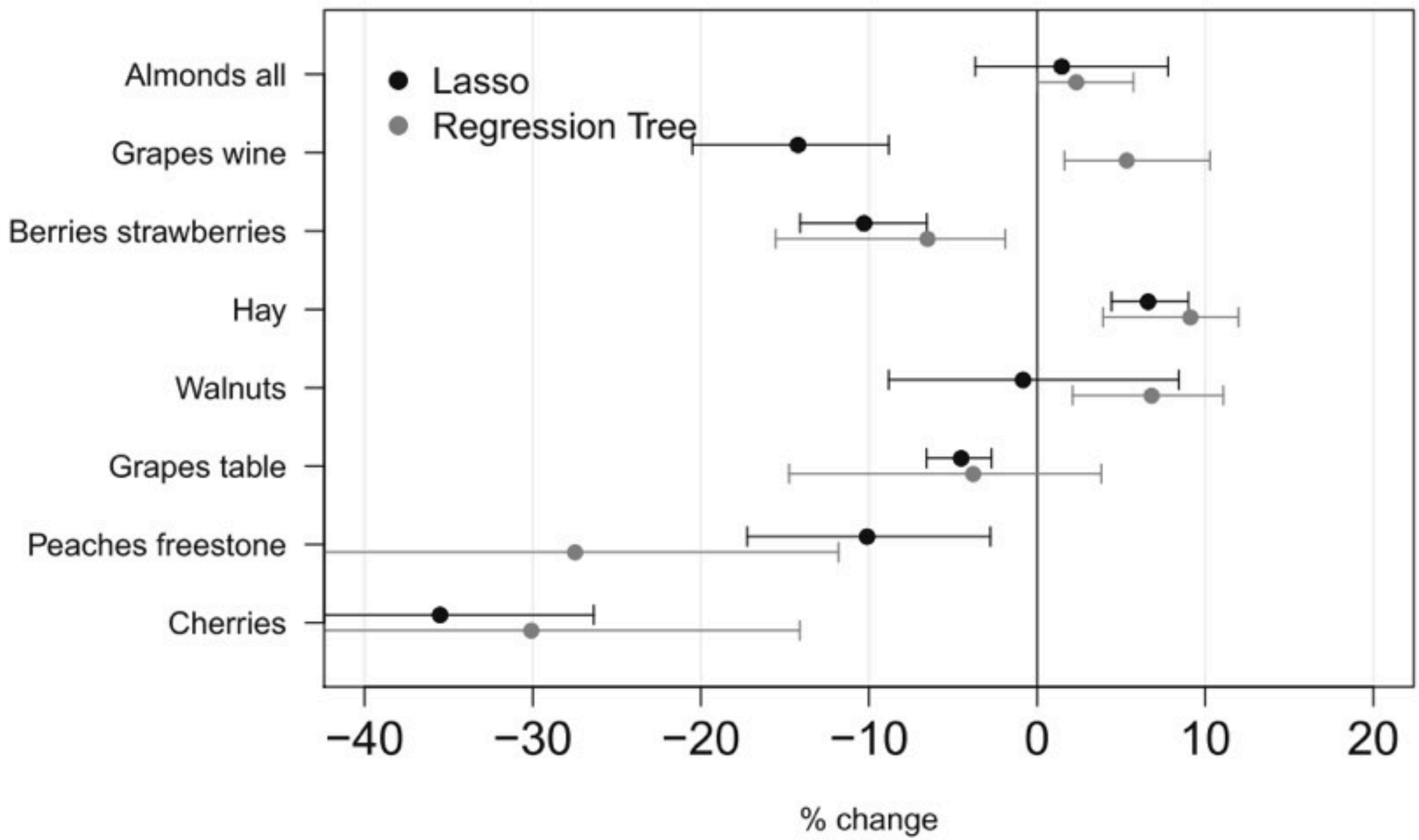
Temperature sensitivity varies by month.



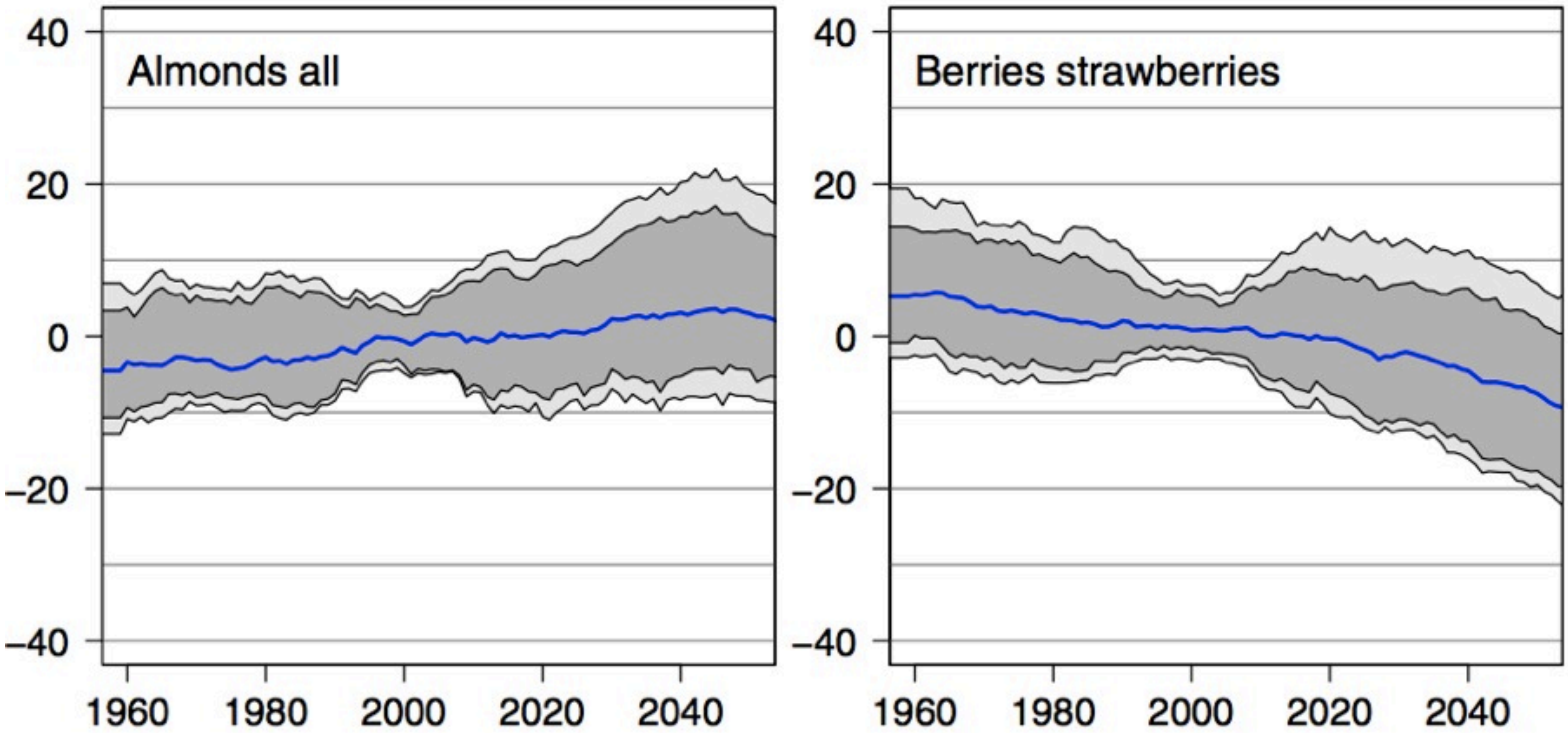
Almond Yields as a function of February minimum temperature.



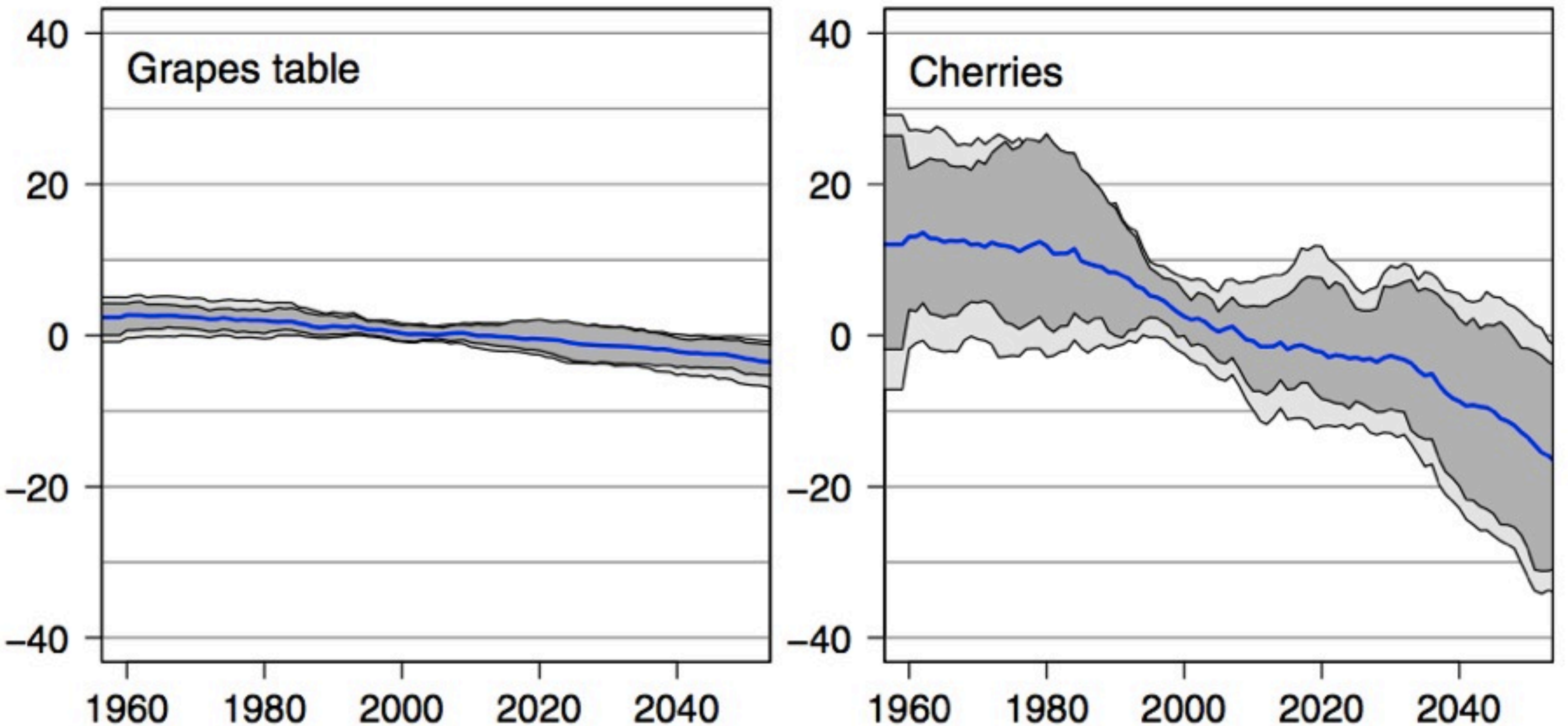
Predicted impact of 2 degree warming on yields.



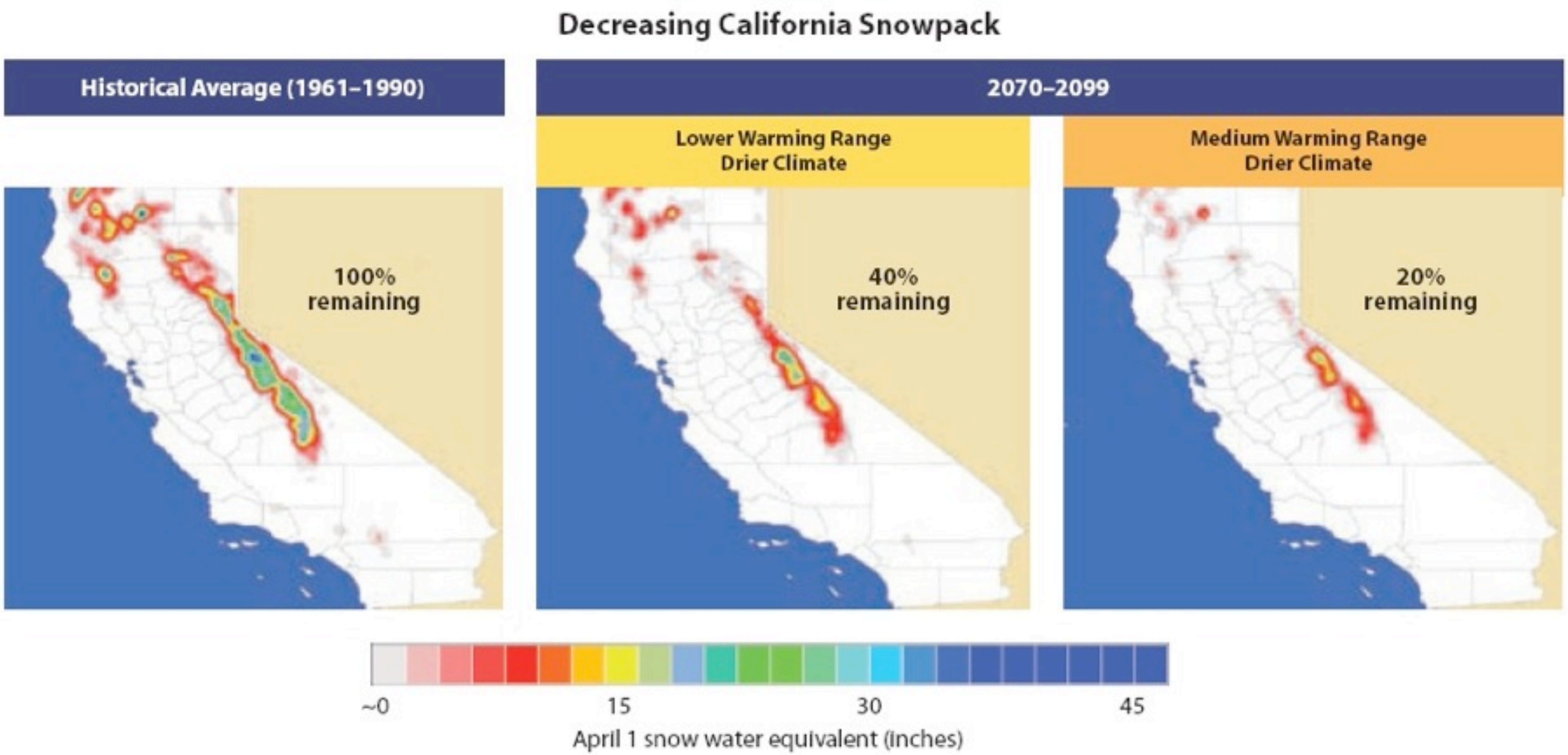
Projected impacts statewide.



Projected impacts statewide.



All of this ignores the availability of irrigation water.



Conclusions

- Studying impacts of climate requires good understanding of
  - Weather sensitivity of crops
  - Adaptation opportunities
  - Forecasts of Climate/Weather
  - Markets and Price sensitivities
- Currently predicted impacts on cherries cause for concern.
- Largest uncertainty is irrigation water

Thank you!

- auffhammer@berkeley.edu